

# Thidiazuron, a Non-Metabolized Cytokinin, Shows Promise in Extending the Life of Potted Plants

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## Abstract

Application of low concentrations of thidiazuron (N-phenyl-N'-1,2,3-thiadiazol-5-yl urea, TDZ) has been shown to be a very effective means of delaying leaf yellowing in cut flowers such as alstroemeria, stock, lilies and tulips. We examined the possible use of this compound for delaying leaf yellowing in a range of potted plants, including geranium, freesia, *Ornithogalum*, and *Euphorbia fulgens*. Spray treatments with 2 to 10 µM TDZ at the end of the production cycle had significant, sometimes spectacular effects on the postharvest performance of most species studied. In addition to a considerable delay in leaf yellowing and/or abscission in most species tested, TDZ application improved display performance in a number of species. In geranium, for example, the individual florets on TDZ-treated plants had a significantly longer life than those on control plants. In *E. fulgens*, flowers lasted longer, and more flowers opened on the TDZ-treated plants. Our results indicate significant potential for TDZ as a tool to improve the postharvest life of potted flowering and foliage plants.

## INTRODUCTION

Leaf yellowing, senescence, and abscission are significant problems that reduce the marketability and longevity of many cut flowers and potted flowering plants, including alstroemeria, lilies and chrysanthemums (Staby and Erwin, 1977; Han, 1995; Ferrante et al., 2002). In addition to the visual quality implications of leaf yellowing, it may have a physiological effect in reducing the photosynthesis that is crucial for normal flower development and longevity (Reid et al., 2002).

The plant growth hormone cytokinin appears to play a key role in delaying leaf yellowing. Application of the synthetic cytokinin benzylaminopurine (BAP) to leaves delays their yellowing and senescence (Richmond and Lang, 1957). This chemical (registered as Maxcel by Valent Bioscience and as Exilis by Fine Agrochemicals), combined with another plant growth regulator with anti-senescence activity, gibberellic acid (GA), is marketed commercially as "Fascination-BA+GA" (Valent Bioscience, Libertyville, IL) for preventing leaf yellowing in cut chrysanthemum flowers and potted roses and Easter lilies (Tjosvold et al., 1994; Han, 1997; Funnell and Heins, 1998; Ranwala et al., 2000). These chemicals are relatively effective in delaying leaf yellowing, but they are expensive, and their effect is short-lived, presumably because they are metabolized by the plant tissue. In addition, the addition of GA to the treatment, while providing a useful synergy in terms of reducing leaf yellowing, frequently results in undesirable 'stretching' of the plants.

Thidiazuron (TDZ), an inexpensive and non-metabolized phenyl-urea compound, has been shown to have a potent cytokinin-like activity at 50-100 times lower concentrations than BAP (Genkov and Iordanka, 1995). TDZ is commonly used at high concentrations as a defoliant in cotton production ('Dropp') (Malik et al., 2002) and at low concentrations for tissue regeneration in culture (Mok et al., 2000; Singh and Syamal,

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2001). Ferrante et al. (2002, 2003) have demonstrated that TDZ dramatically retards chlorophyll degradation in leaves of cut flowers of alstroemeria, tulips and chrysanthemums. TDZ also was reported to markedly delay the onset of leaf senescence in *Pelargonium* (Mutui et al., 2005) and to reduce flower abscission and the senescence of leaves and flowers in cut inflorescences of phlox and lupins (Sankhla et al., 2003, 2005). Although the exact mode of action of TDZ is not well known, evidence suggests that TDZ can modulate cytokinin biosynthesis and/or metabolism, and may mimic the activity of auxin (Murthy et al., 1998; Mok et al., 2000). It has been hypothesized that the long-lived cytokinin effect provided by TDZ treatment not only prevents leaf yellowing, but also reduces ethylene sensitivity (Dinesh et al., 1996; Ferrante et al., 2002; Sankhla et al., 2005).

Here we report the effects of spray-application of TDZ on leaf yellowing and display quality of potted plants.

## MATERIALS AND METHODS

### Plant Materials

Plants of freesias, *Ornithogalum* and *Euphorbia fulgens* were obtained from local nurseries at normal production maturity. Rooted geranium cuttings obtained from a commercial supplier were transplanted into 4 ½-inch pots and grown to commercial maturity in a greenhouse at the University of California, Davis. The plants were maintained at 21°C day/16°C night with natural photoperiods and full natural light. Temperatures sometimes exceeded these limits. The plants were fertilized during irrigation with Miracle-Gro Professional Excel (Scotts-Sierra, Marysville, OH). All open florets were removed from each plant before starting the experiment. When the first florets on the next developing inflorescence had opened (which we considered to be commercial maturity), the plants were sprayed with water or with different concentrations of TDZ. Plants of other species were sprayed with treatment solutions on arrival at UC Davis.

### TDZ Treatment

Plants were sprayed in the greenhouse to runoff (approximately 25 ml of the solution per pot) with 0 (distilled water as a control), 5 and 10 µM TDZ using portable spray bottles. After spraying, the plants were allowed to dry for 3 hours and then packed into commercial shipping boxes. The plants were kept in darkness for 48 hours at 20°C to simulate shipping and then placed in display in a simulated interior environment [20°C, 60% relative humidity, 12 h/day light from cool-white fluorescent lamps ( $18 \mu\text{E} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ )] for evaluation of their postharvest performance. Plants were irrigated as needed with water. Each treatment normally included 8 replicate plants.

### Evaluation of Postharvest (Postproduction) Quality

The performance of plants was evaluated at intervals after removal from the simulated transportation. A range of parameters, depending on the species, were recorded throughout the experiment, including number of yellowed and dropped leaves, wilted and dropped flowers, and flower buds. Floret longevity (recorded in geranium) was determined by tagging replicate florets on their day of opening, and noting the day on which the petals abscised from each tagged floret.

### Statistical Analysis

Treatments were arranged in a completely randomized design with 8 pots/treatment and analyzed using standard techniques.

## RESULTS

### Effects of TDZ on Leaf Yellowing

Spraying finished plants of freesia, geranium, *Ornithogalum*, and *Euphorbia fulgens* with 5 µM or 10 µM TDZ resulted in dramatic reduction in leaf yellowing (Figs. 1 to 4).

The time course of leaf yellowing (shown for freesia) and leaf abscission (shown for geranium) showed exponential increases with time in the display environment in the control plants (Fig. 2). Treatment with 10 µM TDZ almost completely eliminated these problems.

### Effects on Flower Life

In a preliminary experiment using *E. fulgens*, we observed that TDZ application not only prevented leaf yellowing, but also extended flower life and increased flower number (Fig. 3). These effects were further quantified in geranium (Fig. 4), by determining the life of individual florets in the first opening inflorescence. The data show a significant increase in floret life in the TDZ-treated plants (Fig. 5), which explains their improved display quality.

## DISCUSSION

The dramatic effects of TDZ application on post-production leaf yellowing in potted flowering plants mirrors the responses already reported in cut flower species (Ferrante et al., 2002, 2003). In both monocotyledonous (freesia, *Ornithogalum*) and dicotyledonous (geranium, *Euphorbia*) taxa, leaf yellowing was almost completely eliminated by the treatment of low concentrations of TDZ. We observed no phytotoxicity or other negative effects of the treatments on plants tested, which therefore appear to offer a valuable tool for improving post-production performance of potted plants. TDZ treatment did not cause the changes in plant architecture that are a common side-effect of the commercial tools presently available for delaying leaf yellowing (comprising a mixture of BA and GA).

It was interesting to note that there were correlative effects of the TDZ treatment on floral display quality. In geranium, this appeared to be the result of increased floret longevity. In this species, it may be that the action of TDZ is to reduce ethylene sensitivity and thereby delay the onset of petal abscission, which normally ends floret life (Cameron and Reid, 2001). In *E. fulgens*, we observed improved floret longevity, and continued floret opening in the treated plants, and hypothesize that the maintenance of photosynthesis results in improved carbohydrate status, which is essential to maintaining floral display in flowering plants (Reid et al., 2002). We plan to examine the basis for this striking effect in future experiments.

## ACKNOWLEDGEMENTS

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## Literature Cited

- Cameron, A.C. and Reid, M.S. 2001. 1-MCP blocks ethylene-induced petal abscission of *Pelargonium peltatum* but the effect is transient. Postharvest Biology and Technology 22:169-177.
- Dinesh, R., Sankhla, N., Sankhla, D., Kachhwaha, S. and Upadhyaya, A. 1996. Effect of thidiazuron on growth, antioxidants and lipid peroxidation in chickpea seedlings. Proc. Plant Growth Reg. Soc. Amer. 23:211-216.
- Ferrante, A., Hunter, D., Hackett, W. and Reid, M. 2002. Thidiazuron-a potent inhibitor of leaf senescence in *Alstroemeria*. Postharvest Biology and Technology 25:333-338.
- Ferrante, A., Tognoni, F., Mensuali-Sodi, A. and Serra, G. 2003. Treatment with

- Thidiazuron for preventing leaf yellowing in cut tulips and chrysanthemum. *Acta Hort.* 624:357-363.
- Funnell, K.A. and Heins, R.D. 1998. Plant growth regulators reduce postproduction leaf yellowing of potted *Asiflorum* lilies. *HortScience* 33:1036-1037.
- Genkov, T. and Iordanova, I. 1995. Effect of cytokinin-active phenylurea derivatives on shoot multiplication, peroxidase and superoxide dismutase activities of in vitro cultured carnation. *Bulgarian Journal of Plant Physiology* 21:73-83.
- Han, S.S. 1995. Growth regulators delay foliar chlorosis of Easter lily leaves. *J. Am. Soc. Hort. Sci.* 120:254-258.
- Han, S.S. 1997. Preventing postproduction leaf yellowing in Easter lily. *J. Am. Soc. Hort. Sci.* 122:869-872.
- Malik, M.N.A., Shabab, U.D., Makhdom, I. and Chaudhry, F.I. 2002. Use of thidiazuron as an harvest aid in early and late planted cotton. *Internat. J. Agric. Biol.* 4:71-73.
- Mok, M.C., Martin, R.C. and Mok, D.V.S. 2000. Cytokinins: Biosynthesis, metabolism and perception. *In Vitro Cell. Dev. Biol. Plant* 36:102-107.
- Murthy, B.N.S., Murch, S.J. and Saxena, P.K. 1998. Thidiazuron: A potent regulator of in vitro plant morphogenesis. *In vitro Cell. Dev. Biol. Plant* 34:267-275.
- Mutui, T.M., Mibus, H. and Serek, M. 2005. Effects of thidiazuron, ethylene, abscisic acid and dark storage on leaf yellowing and rooting of *Pelargonium* cutting. *J. Hort. Sci. Biotech.* 80:543-550.
- Ranwala, A.P., Miller, W.B., Kirk, T.I. and Hammer, P.A. 2000. Ancymidol drenches, reversed greenhouse temperatures, postgreenhouse cold storage, and hormone sprays affect post-harvest leaf chlorosis in Easter lily. *J. Am. Soc. Hort. Sci.* 125:248-253.
- Reid, M.S., Wollenweber, B. and Serek, M. 2002. Carbon balance and ethylene in the postharvest life of flowering hibiscus. *Postharvest Biology and Technology* 25:227-233.
- Richmond, A.E. and Lang, A. 1957. Effect of kinetin on protein content and survival of detached xanthium leaves. *Science* 125:650-651.
- Sankhla, N., Mackay, W.A. and Davis, T.D. 2003. Reduction of flower abscission and leaf senescence in cut phlox inflorescence by thidiazuron. *Acta Hort.* 628:837-841.
- Sankhla, N., Mackay, W.A. and Davis, T.D. 2005. Effect of thidiazuron on senescence of flowers in cut inflorescences of *Lupinus densiflorus* Benth. *Acta Horticulturae* 669:239-243.
- Singh, S.K. and Syamal, M.M. 2001. A short pre-culture soak in thidiazuron or forchlorfenuron improves axillary shoot proliferation in rose micropropagation. *Scientia Horticulturae* 91:169-177.
- Staby, G.L. and Erwin, T.D. 1977. The storage of easter lilies. *Florists' Review* 161:38.
- Tjosvold, S.A., Wu, M.-J. and Reid, M.S. 1994. Reduction of postproduction quality loss in potted miniature roses. *HortScience* 29:293-294.

## Figures



Fig. 1. Effect of 5  $\mu\text{M}$  TDZ on leaf yellowing in flowering plants of *Ornithogalum*. Plants were sprayed to runoff at commercial maturity with TDZ (left) or water (right), then, after a 3 days transport simulation, were held in a display environment for 4 weeks.

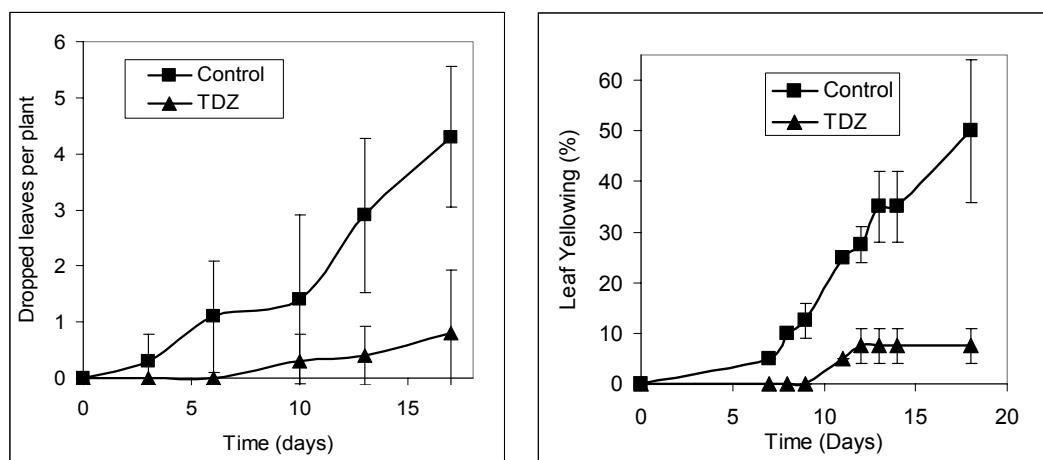


Fig. 2. Effect of TDZ on leaf quality in flowering potted plants. Plants at commercial maturity were sprayed to runoff with water or 10  $\mu\text{M}$  TDZ, then, after a 3 days transport simulation, were held for observation in the display environment. A. Leaf drop (number/plant) in geranium. B. Leaf yellowing (% leaves showing >50% yellow) in freesia. Data are the means  $\pm$  S.D. of 8 replicate pots.



Fig. 3. Effect of 5  $\mu\text{M}$  TDZ on display quality of flowering plants of *Euphorbia fulgens*. Plants were sprayed to runoff at commercial maturity with water (left), or 5  $\mu\text{M}$  TDZ (right) then, after a 3 days transport simulation, were held in the display environment for 3 weeks.



Fig. 4. Effect of TDZ on display quality of flowering geranium plants (*Pelargonium hortorum* 'Tango'). Plants at commercial maturity were sprayed to runoff with water (left), 5  $\mu\text{M}$  TDZ (center) or 10  $\mu\text{M}$  TDZ (right), then, after a 3 days transport simulation were held in the display environment for 3 weeks.

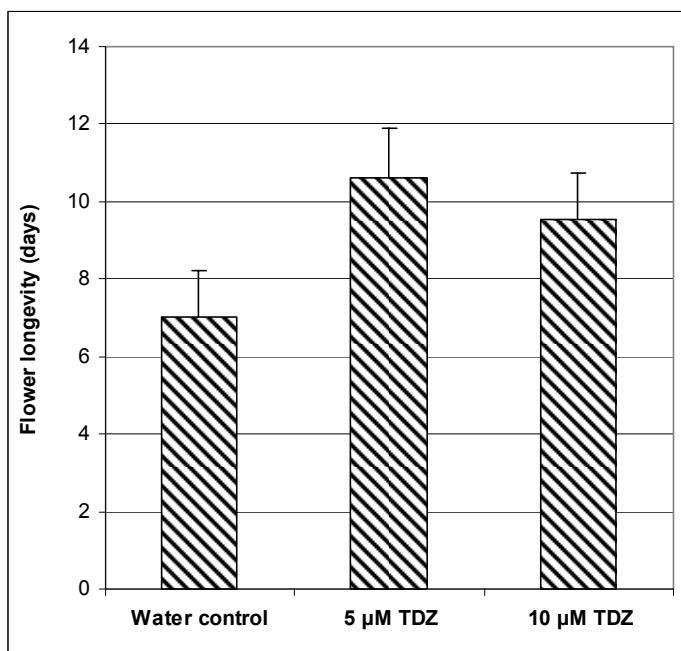


Fig. 5. Effect of TDZ on floret longevity in flowering geranium plants (*Pelargonium hortorum* 'Tango'). Plants at commercial maturity were sprayed to runoff with TDZ or water, then, after a 3 days transport simulation were held in a display environment for 3 weeks. Individual florets were tagged on the day they opened, and the date when all their petals had abscised was recorded. Data are the means $\pm$ S.D. of 15 florets/treatment.

